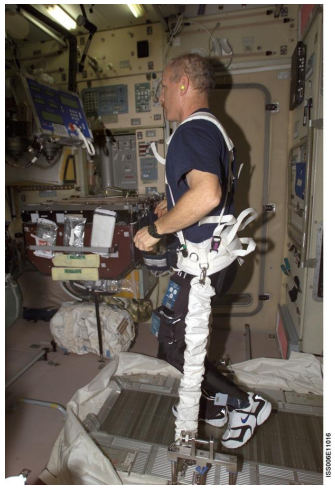
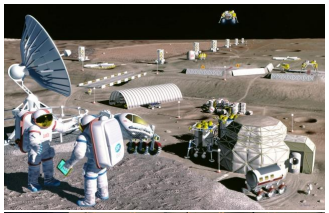
GRC Exercise Countermeasures Project

Project Overview and Research Collaborations



Presented by:

Gail P. Perusek, Engineering Development Division, NASA GRC

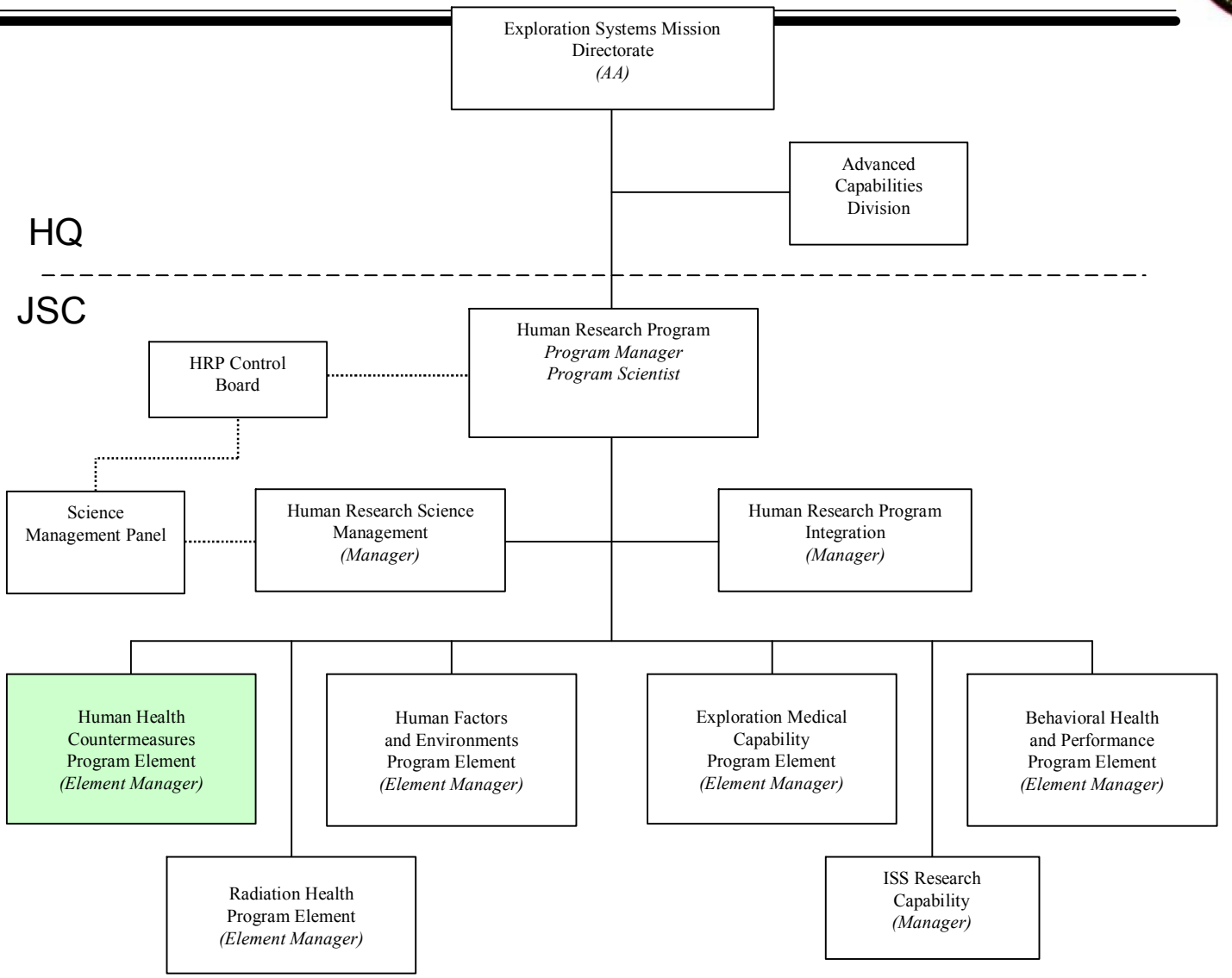
Managed out of Exploration Systems Division, Human Health and Performance Systems Project Office, NASA GRC /PTH

February 3, 2006 DLT Forum

Presentation Outline

- Program Organization HQ – JSC – GRC
- Exercise Countermeasures Project (ECP) Overview
- Exercise Countermeasures at NASA GRC
  - Background – Bone Loss in Astronauts
  - Zero-g Locomotion Simulator at Cleveland Clinic
  - Exercise Countermeasures Laboratory at GRC
  - Computational Modeling of Exercise System
  - Biometric Data Sensing and Analysis
  - On-orbit / Flight Hardware Development
- Strategic Partnerships / Research Collaborations

Human Research Program Management Structure

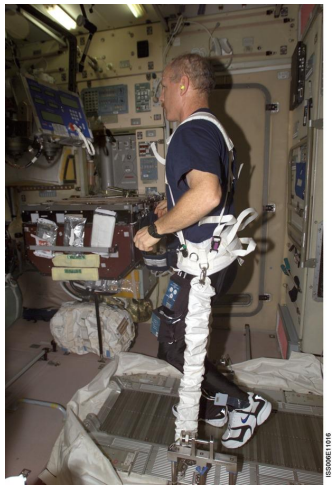


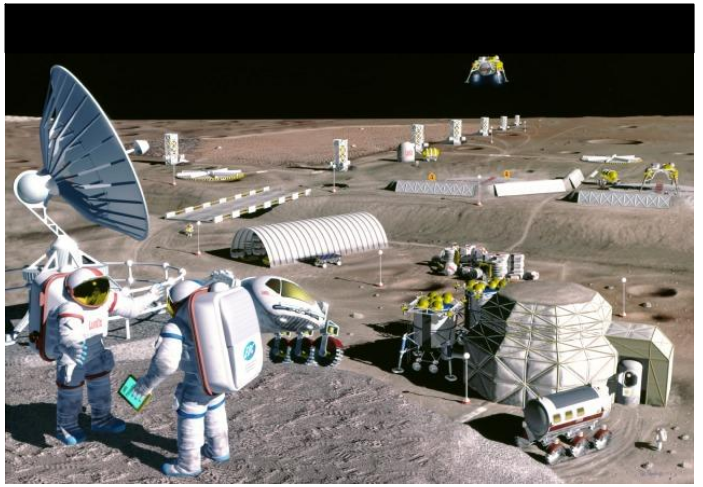
Human Health Countermeasures Projects (JSC)

- Exercise Countermeasures Project
- Fractional Gravity Project
- Extra Vehicular Activity (EVA) Physiological Systems Project
- Non Exercise Physiological Countermeasures Project
- Facilities Project (e.g., Bedrest)

Exercise Countermeasures Project

Maintaining health and fitness during space missions is critical for preserving performance for mission critical tasks both in transit and on the surface.



Project Objective

Develop and provide exercise countermeasure prescriptions and systems for space exploration that are effective, optimized, and validated and meet medical, vehicle, and habitat requirements.

Effects of Microgravity on Bone

On-orbit – the skeleton is *unloaded*

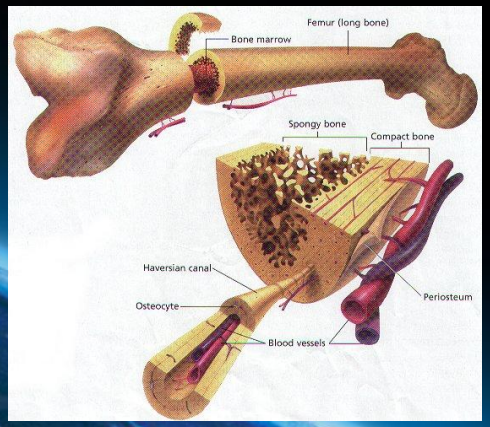
- decrease in weight - bearing activity
- decrease in muscle strength

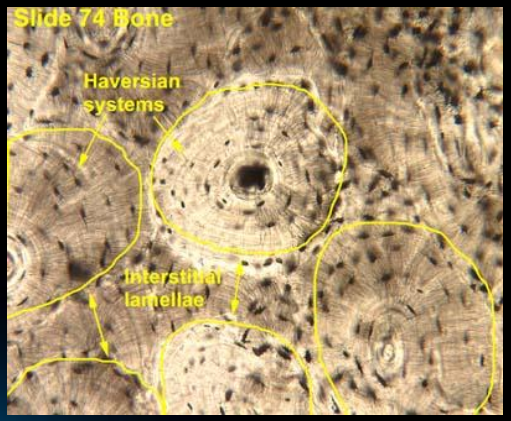
Decreased bone formation in weight-bearing bones

- typically 1 to 1.5 % bone density loss per month in space

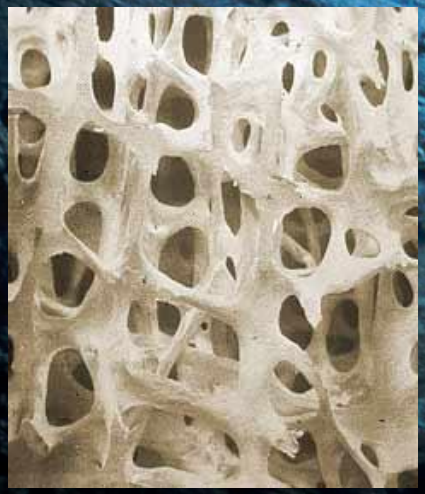
Bone resorption increases and exceeds formation – increase in urinary calcium excretion

Bone Remodeling – “Adaptive Response”

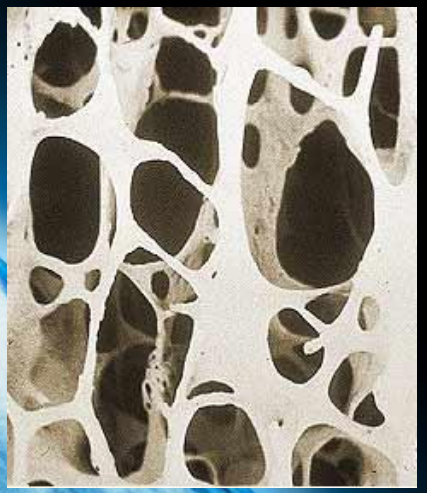




Normal bone



Osteoporotic bone



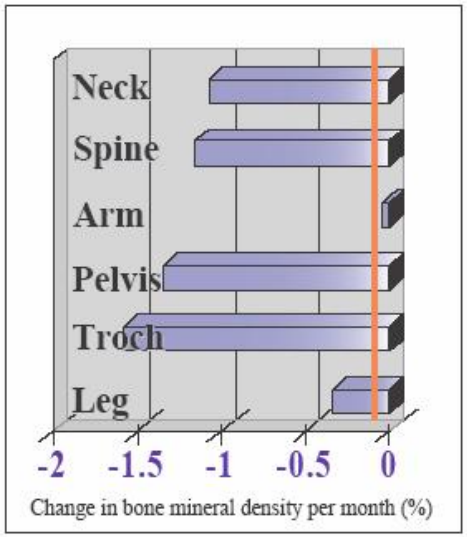
Space flight – induced bone loss

Space Flight

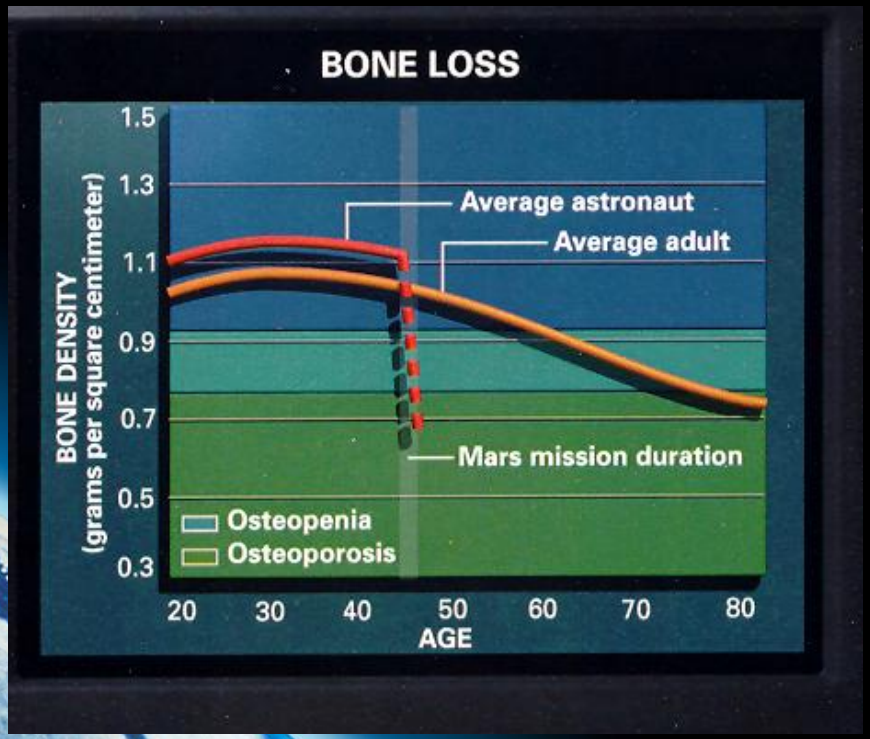
1-2% per month loss of bone mineral density in the lower extremity.
No loss in upper extremity BMD.
(LeBlanc et al. 1996)

Earth

0.08-0.16% per month loss of BMD in Post-menopausal Osteoporosis.
(Ahlborg et al., 2003)



BMD changes on MIR
(4-14 month missions)
LeBlanc et al., 1996



Ultimate concern with bone loss is FRACTURE

History of Space Exercise Equipment

GEMINI
- ❖ Isometrics
- ❖ Bungee exercise

APOLLO
- ❖ Rope-pull system

SKYLAB II
- ❖ Cycle ergometer

SKYLAB III
- ❖ Cycle ergometer
- ❖ MKI isokinetic rope-pull
- ❖ MKII handle/spring assembly

SKYLAB IV
- ❖ Cycle ergometer
- ❖ MKI isokinetic rope-pull
- ❖ MKII handle/spring assembly
- ❖ Treadmill

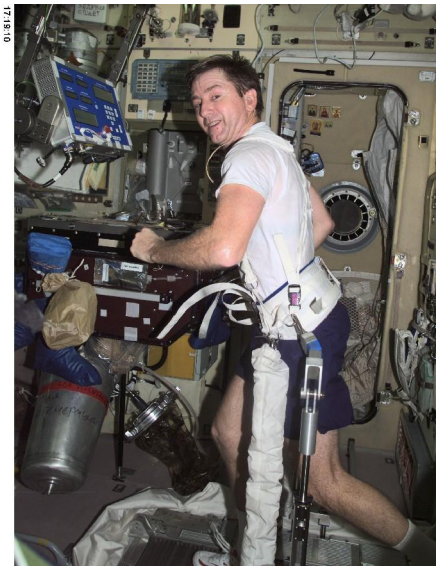
SHUTTLE
- ❖ Cycle ergometer
- ❖ Rower
- ❖ Treadmill

SOYUZ-SALYUT & MIR
- ❖ Cycle ergometer
- ❖ Treadmill
- ❖ Penguin Suit
- ❖ Russian Expanders

International Space Station
- ❖ Cycle Ergometer (CEVIS)
- ❖ Velo Ergometer
- ❖ Treadmill (TVIS)
- ❖ Penguin Suit
- ❖ Resistance Exercise Device (iRED)
- ❖ Russian Expanders

Current ISS Exercise Equipment – U.S.

Cycle Ergometer (CEVIS)



Treadmill with Vibration Isolation and Stabilization (TVIS)

Interim Resistive Exercise Device (iRED)

Exercise Countermeasures Project
GRC Responsibilities

- Operational Enhanced Zero Gravity Locomotion Simulator (eZLS) -ground based testbed will provide a high-fidelity simulation of low and 1/6 g environments
- Improved Subject Load Device (SLD) - Ground based tests & simulation offers the ideal setting to optimize the SLD, harness design, and exercise prescription
- Crew Equipment Optimization - Harness evaluations studies
- VO2 comparison studies in simulated 1/ 6 G, 0 G, and in 1G
- Development of a stand-alone ZLS for JSC Bedrest studies
- Sensor Development with feedback - establishment of real-time, portable, small diagnostics
- Dynamic Computational Modeling – Modeling of exercise interface/structure dynamic forces that affect the body force loads and their time rate of change
- Exercise prescription development based on Daily Load Stimulus (DLS) methodology
- Protocol Evaluation - obtained via the 1G testbed
- High bandwidth data acquisition, near real time analysis and archiving (Based on proven PIMS architecture) – Biometric data and analysis and processing
- Flight Hardware development plans for ECP research on ISS

Exercise Countermeasures Project (2.4.3) Project Content

2.4.3 Exercise Countermeasures Project (ECP)

2.4.3.1 Exercise Integration & Ops

- Project Management
- Project Scientist
- Project Plan and Science Plan development
- Integration of ECP reqmts into Exploration products
- Master schedule
- Meeting coordination and support
- Risk management
- Website updates
- Metrics
- Intercenter (SD, CEV, EB, EVA, etc.) and Intracenter (GRC, NSBRI, AsMA, ACSM, etc.) coordination

2.4.3.2 Ground-Based 0-g R&T

- Investigator Team formation and meetings
- ECP space flight analog proposal development
- Space-flight analog study implementation
- Ground hardware systems for use during exercise countermeasures validation studies
- 0-g Hardware Trade Studies
- Harness Studies
- ARED Physiological Study
- Support to GRC Studies
- ASCR support
- CCF Bedrest Study
- Muscle Fiber Function

2.4.3.3 Ground-Based 1/6g R&T

- Support 1/6-g analog reqmts and hardware development
- Directed research protocols to develop the exercise prescriptions for lunar missions
- Harness Studies
- CEV and Lunar hardware options Trade Studies
- Support to GRC Studies
- ASCR support

2.2.3.4 GRC Engineering/ eZLS Utilization

- 1/6-g analog reqmts and hardware development
- Enhanced Zero gravity Locomotion Simulator (eZLS) ground-based test bed providing high-fidelity simulation of on-orbit exercise
- Computational modeling to reflect a variety of environments (0-g, 1/6, 1/3-g) and exercise modalities
- Subject loading/harness optimization study
- VO2 studies to quantify effects of 1/6 and 1/3g
- Support to JSC Studies / sZLS
- Portable Unit for Metabolic Analysis evaluations

2.4.3.5 ISS Flight R&T

- Existing Grants
  - Flight FOOT Study
  - Proximal Femur Effects
- Other R&T (TBD)

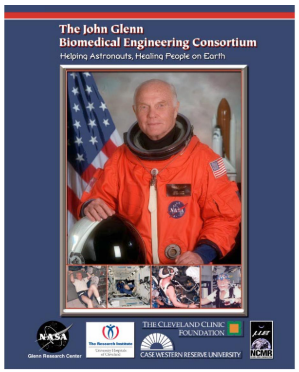
JSC

GRC

JSC & GRC

ECP Key Personnel From GRC / CCF

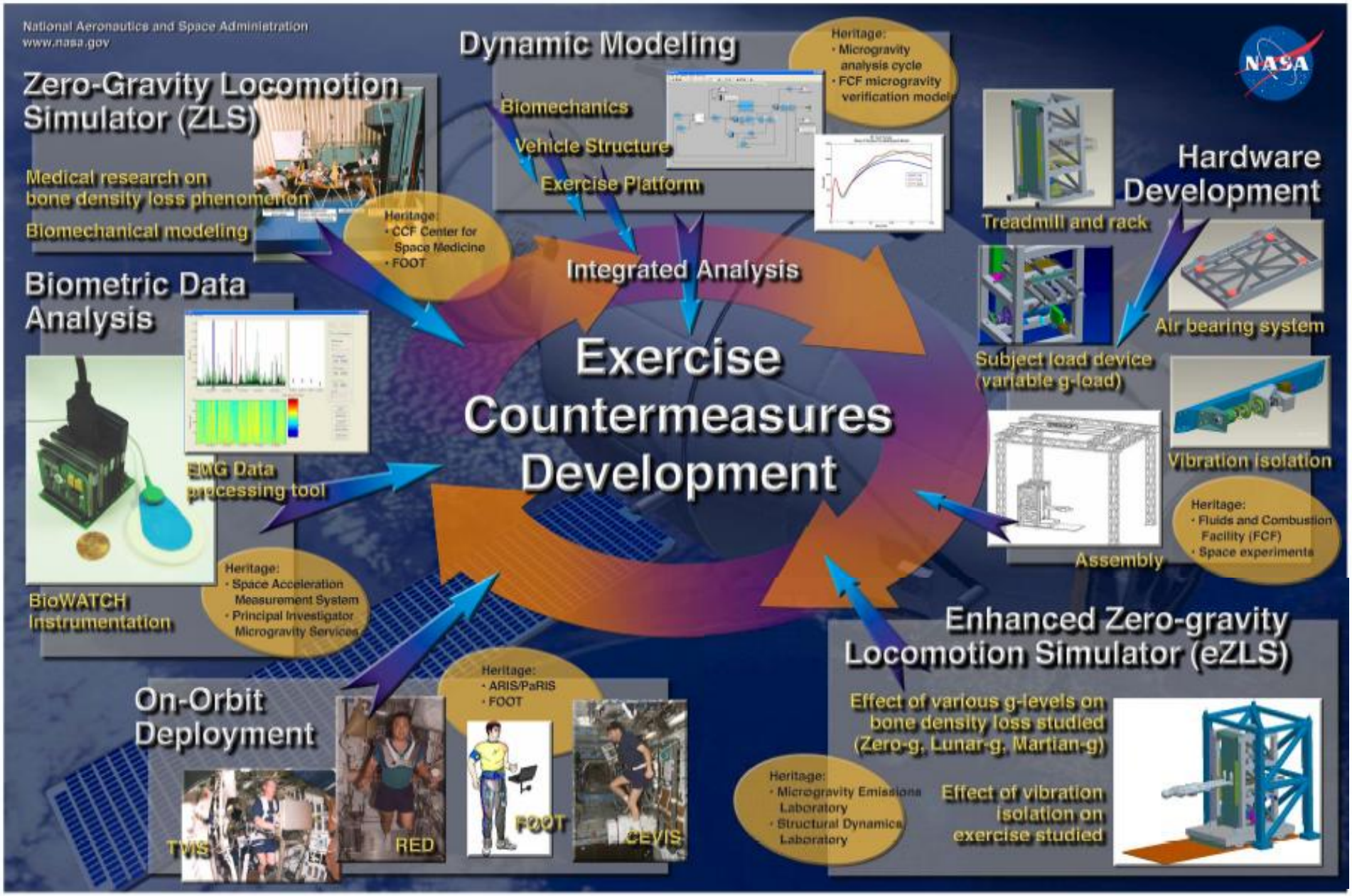
- Marsha Nall (NASA GRC) – Project Manager, Human Health and Performance Systems Office
- Peter R. Cavanagh, PhD, DSc (Cleveland Clinic Foundation) – NSBRI Bone Loss Team Lead
- Kathy Shepherd (NASA GRC) – Deputy Project Manager
- Gail Perusek (NASA GRC) – Project Engineering / Task Lead
- Carlos Grodsinsky, PhD (ZIN Tech) – VP for Technology
- Marcus Just (ZIN Tech) – Senior Engineer, Microgravity Environments / Modeling



ZIN Technologies

The Center for Space Medicine
The Cleveland Clinic

THE CLEVELAND CLINIC FOUNDATION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Treadmill and rack
Air bearing system
Subject load device (variable g-load)
Vibration isolation
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Enhanced Zero-gravity Locomotion Simulator (eZLS)
Effect of various g-levels on bone density loss studied (Zero-g, Lunar-g, Martian-g)
Effect of vibration isolation on exercise studied
Heritage:
· Microgravity Emissions Laboratory
· Structural Dynamics Laboratory

Effect of Interfaces on Functional Loading

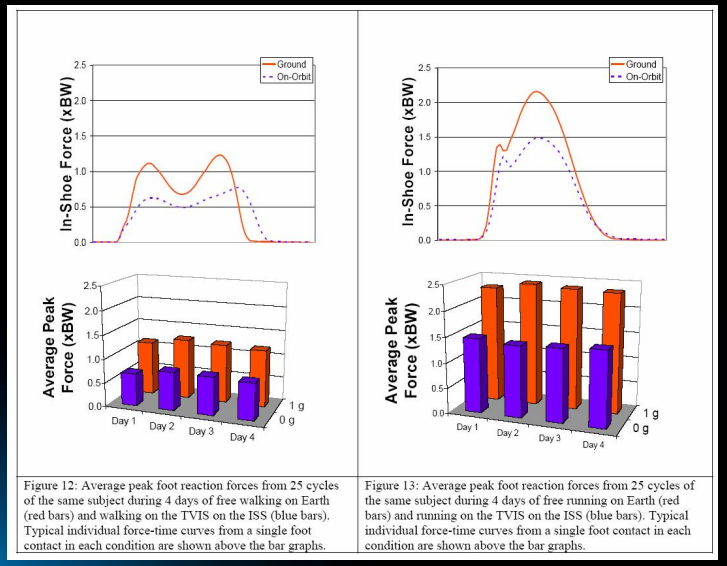


Figure 12: Average peak foot reaction forces from 25 cycles of the same subject during 4 days of free walking on Earth (red bars) and walking on the ISS (blue bars). Typical individual force-time curves from a single foot contact in each condition are shown above the bar graphs.

Figure 13: Average peak foot reaction forces from 25 cycles of the same subject during 4 days of free running on Earth (red bars) and running on the TVIS on the ISS (blue bars). Typical individual force-time curves from a single foot contact in each condition are shown above the bar graphs.

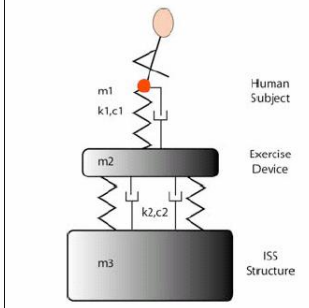


Figure 8: Simplified mass-spring-damper model of human subject, exercise device, and ISS interface.

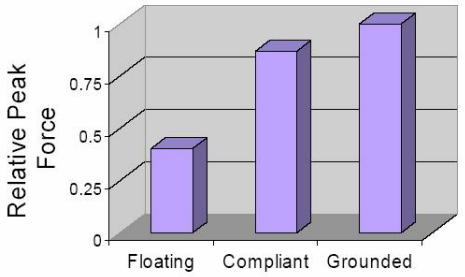


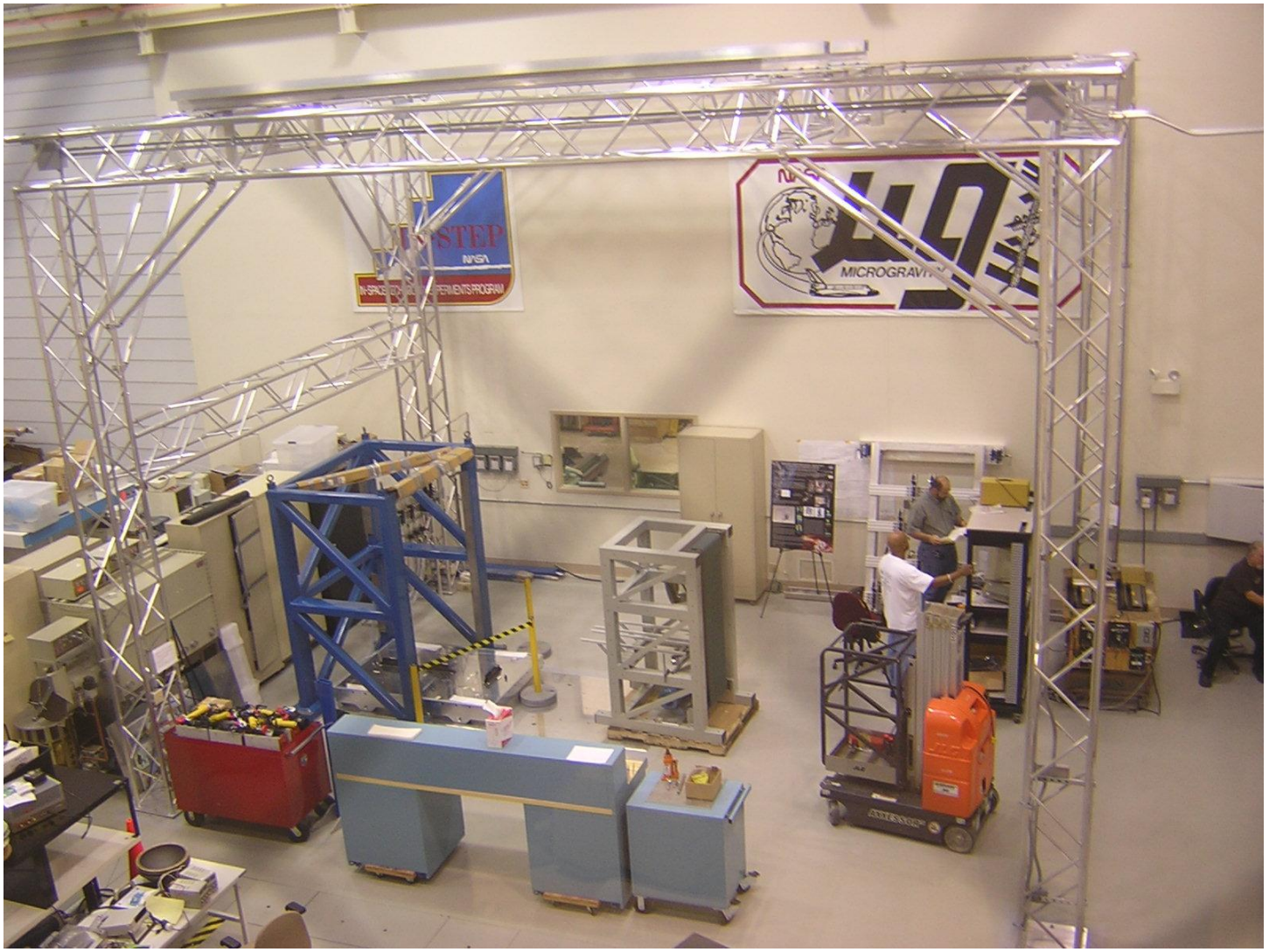
Figure 9: Predicted relative peak force at 3 Hz from the simulation of the three interface conditions.

How do we simulate zero-g exercise on Earth?

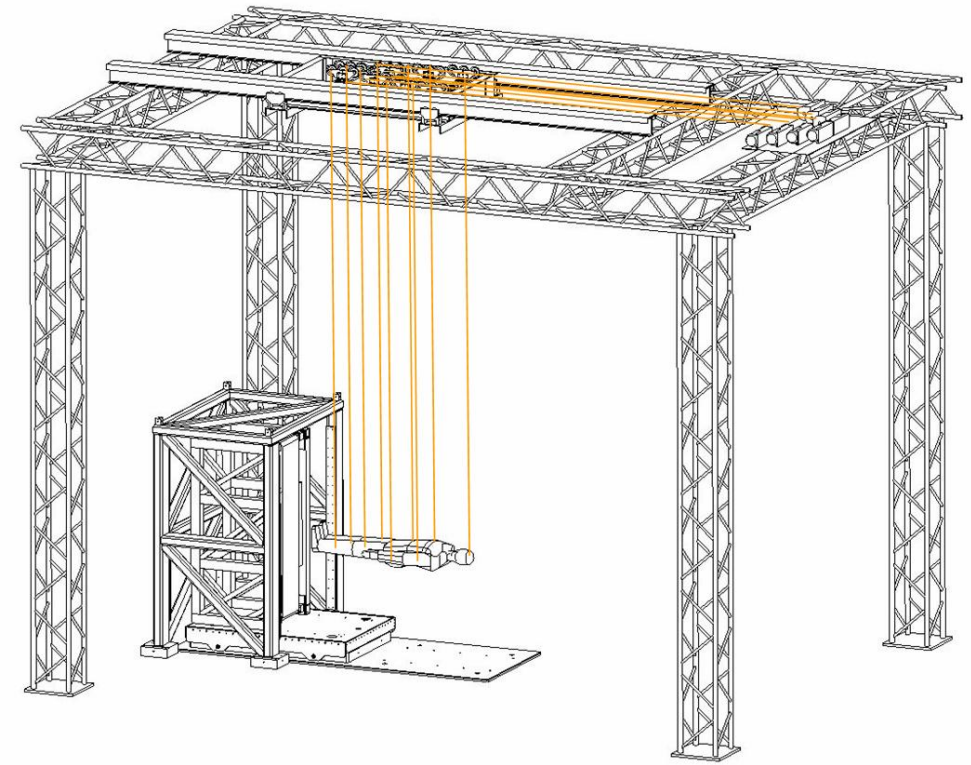
1 g

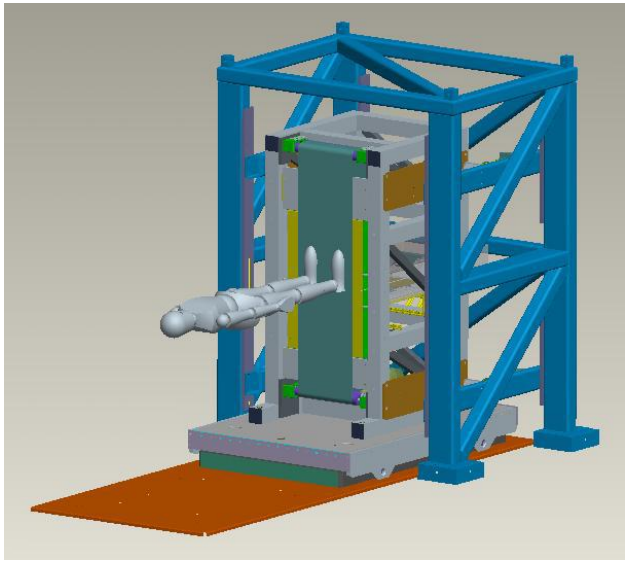
How do we simulate zero-g exercise on Earth?

Exercise Countermeasures Lab – B. 110



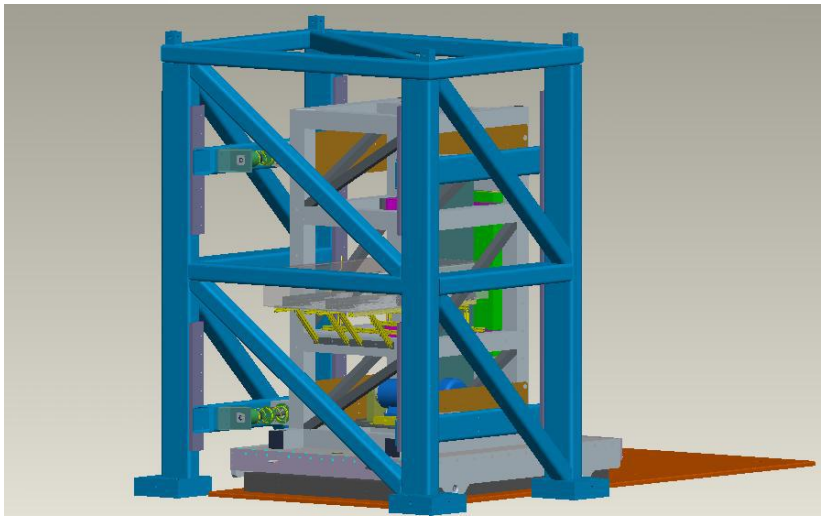
ECL Hardware Overview

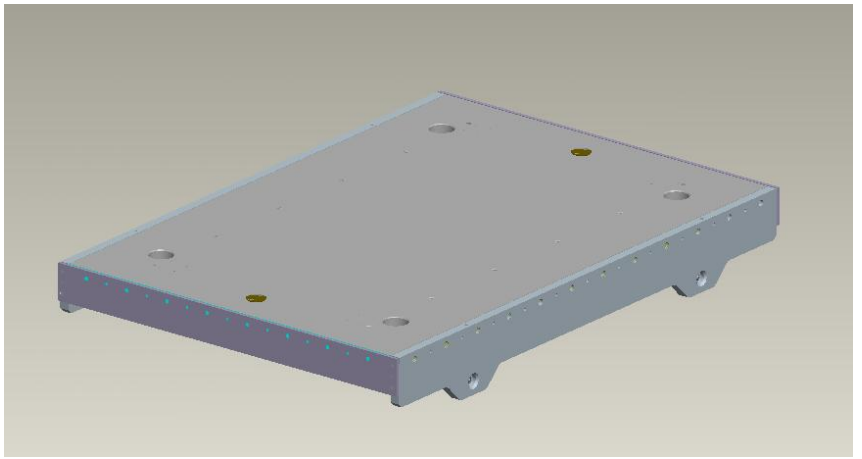


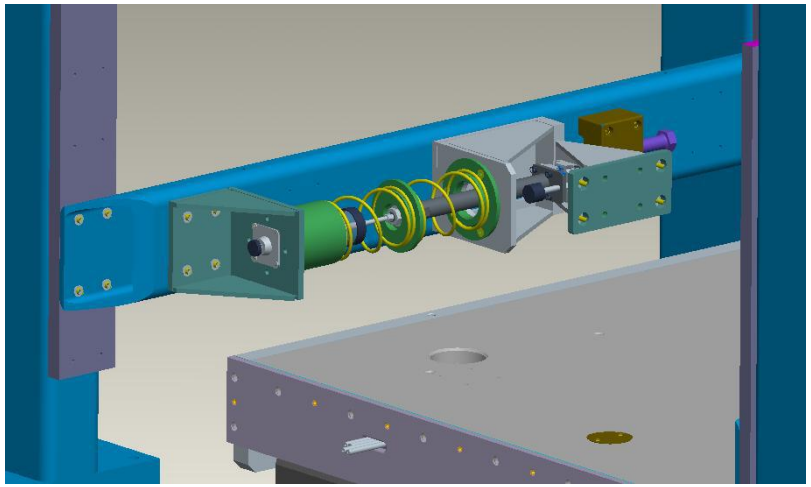


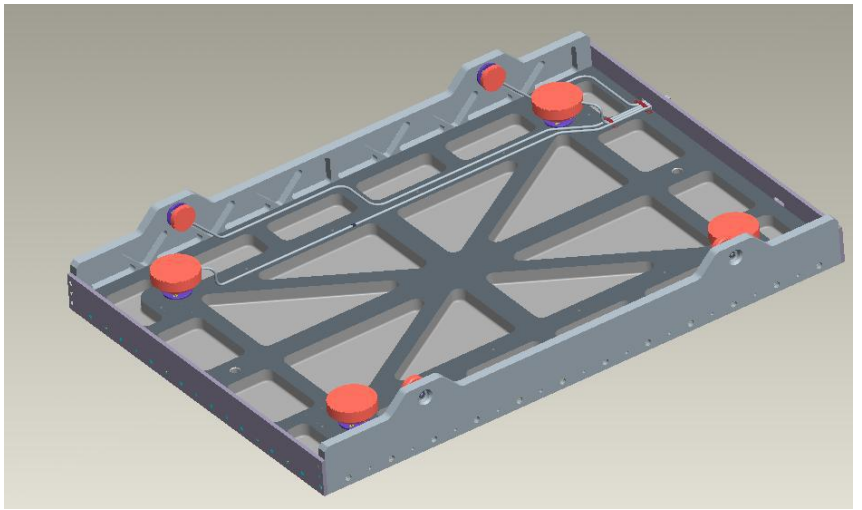
Isometric views of the Exercise Countermeasures Laboratory at NASA GRC

Variably-Compliant Isolators / Air Table









“Walking on Air: NASA’s Floating Treadmill”

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FEATURE

Walking on Air: NASA's Floating Treadmill **01.04.06**

On the space station, astronauts are like superheroes. They twist and flip as easily as Olympic gymnasts and can hoist more weight than power lifters.

Image right: Expedition 9 cosmonaut Gennady I. Padalka (left) and astronaut Edward M. Fincke pose for a photo in the space station's Unity node. Credit: NASA

Living in space is indeed a dream come true, but over time it can cause an astronaut's bones to deteriorate. As NASA prepares to send humans back to the moon and eventually beyond, researchers are looking for new ways to keep astronauts' bones healthy and strong.

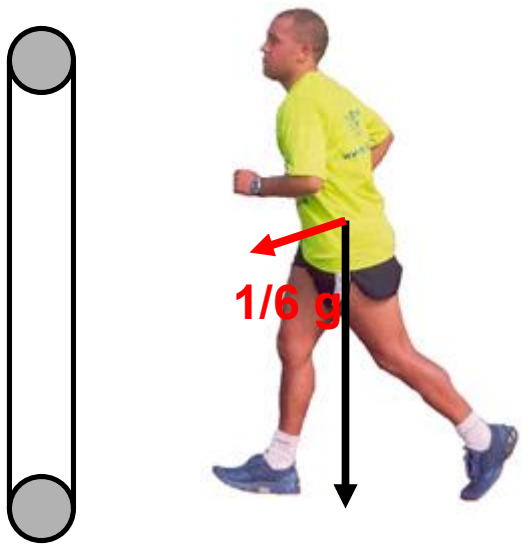
To do so, a team of engineers from NASA's Glenn Research Center and The Cleveland Clinic Foundation have developed a new treadmill that simulates the space environment. They'll begin testing with human participants in early spring.

The information they gather will help NASA design better exercise equipment and develop exercise routines for astronauts. It also could help doctors treat and prevent osteoporosis, a disease that threatens 44 million Americans.

Microgravity and Bone Loss

In the absence of gravity, human bones don't have to perform their primary function of supporting the body's weight. As a result, space station astronauts experience disuse osteoporosis, a type of bone loss common in immobile patients.

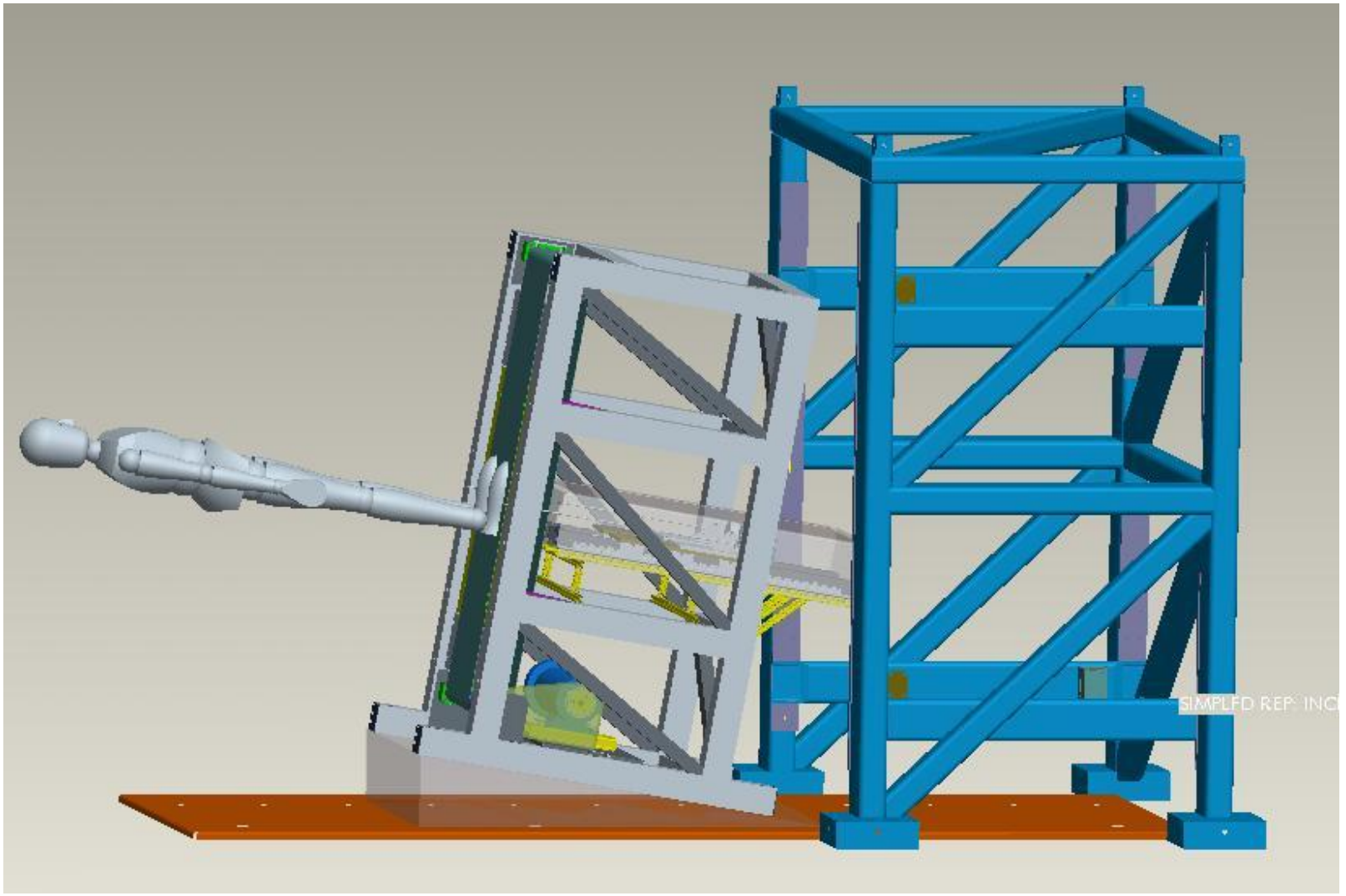
How do you simulate lunar (1/6-g) exercise on Earth?



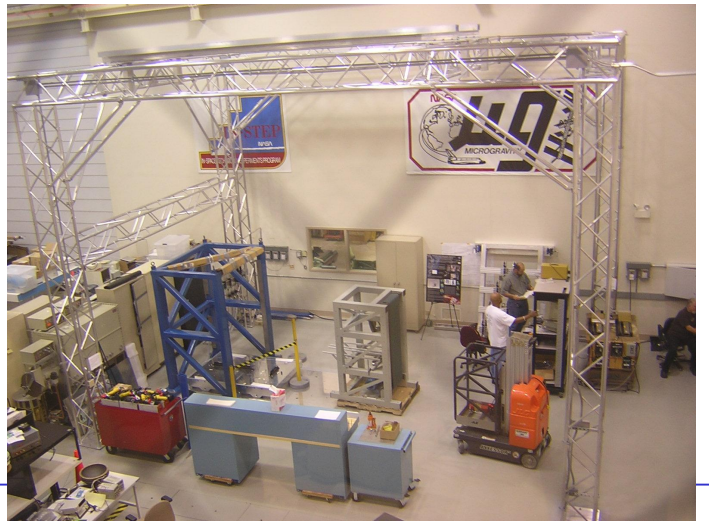
How do you simulate lunar (1/6-g) exercise on Earth?

Walter Cronkite At The Reduced Gravity Simulator
NASA Langley Research Center 8/13/1968 Image # EL-1996-00190

eZLS Inclined Surface for Moon (9.5 deg.)

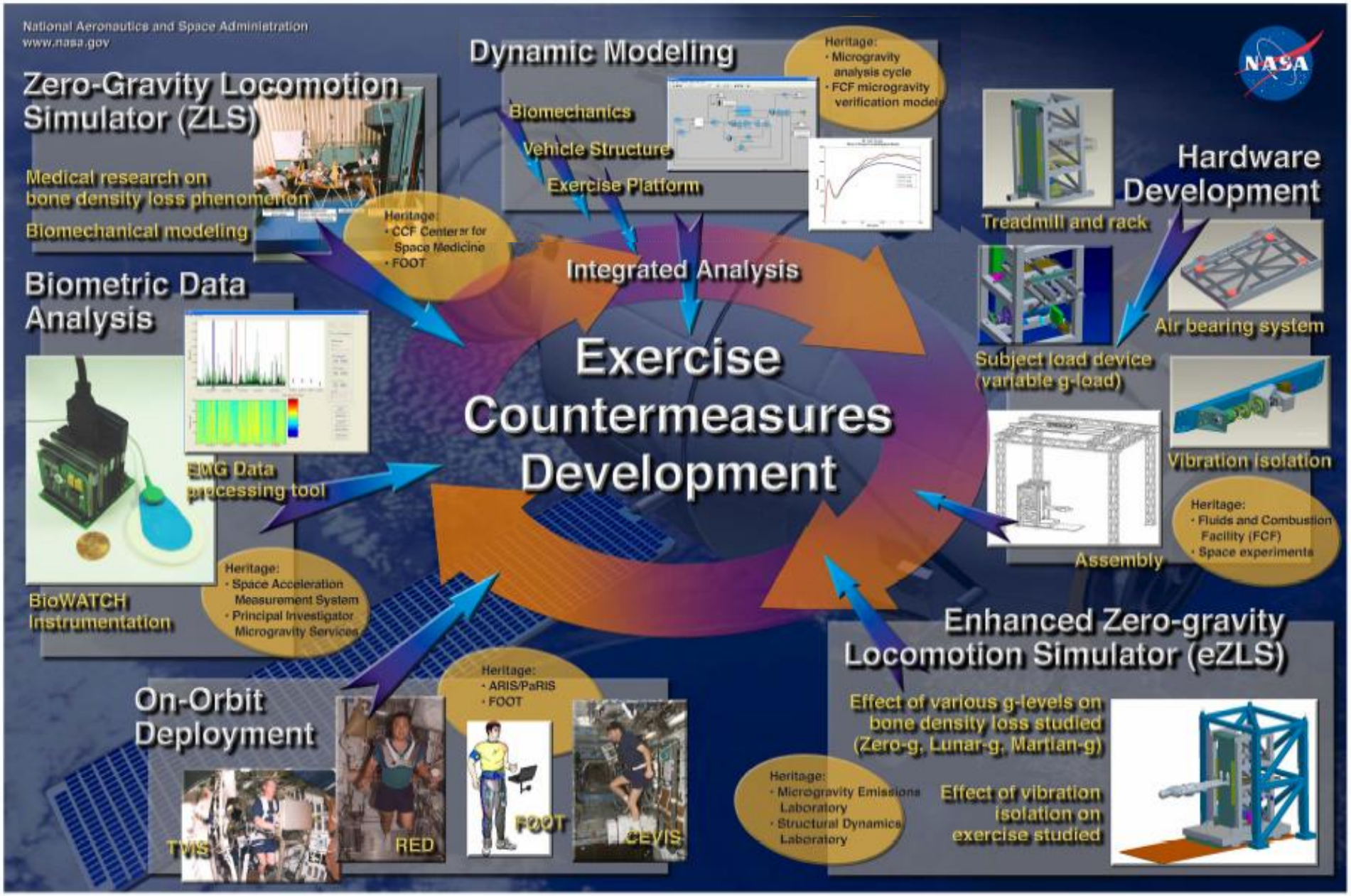


Exercise Countermeasures Lab
A Ground - Based Facility



Mission Statement

The Exercise Countermeasures Laboratory (ECL) at NASA Glenn Research Center serves the NASA Exercise Countermeasures Project (ECP) and exercise community as a whole by providing a ground-based laboratory for simulating in-flight (0-g) and surface (fractional-g) exercise – for developing and validating advanced exercise countermeasure devices, requirements, and exercise prescriptions for Space Exploration.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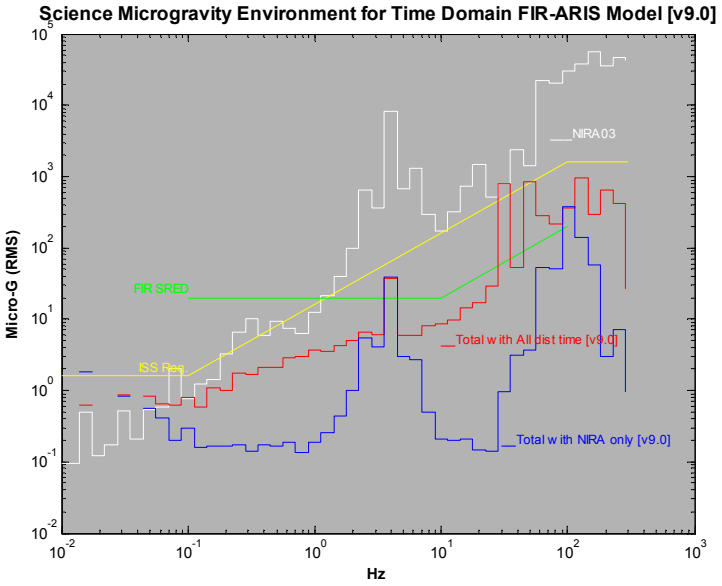
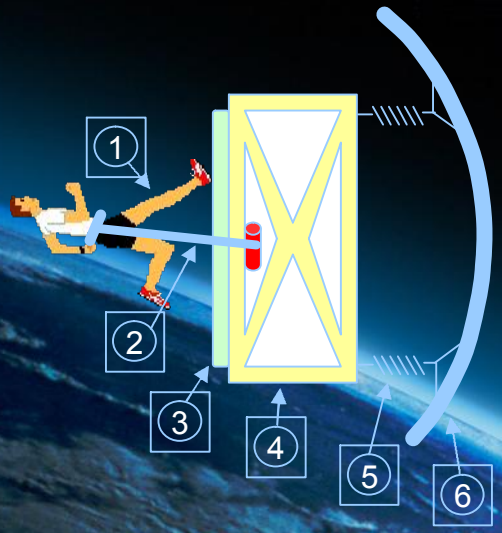
Dynamic Modeling Heritage – On Orbit Environments

- Our approach was already developed and implemented as part of Microgravity Verification for Fluids and Combustion Facility and science payloads using both active and passive vibration isolation technology.
- Expanded and implemented as part of Microgravity Analysis Cycle (MAC), an on-line integrated microgravity acceleration prediction tool. http://exploration.grc.nasa.gov/mac_website/

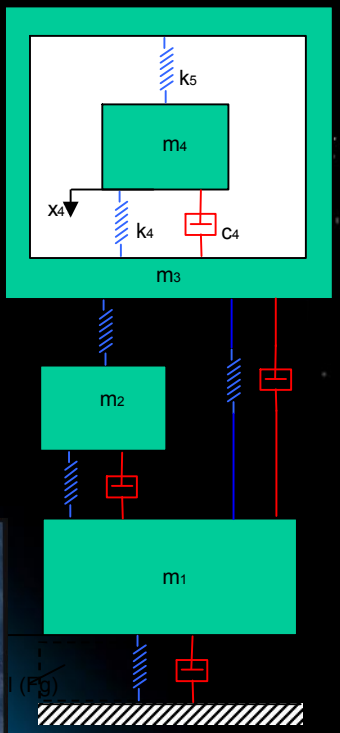


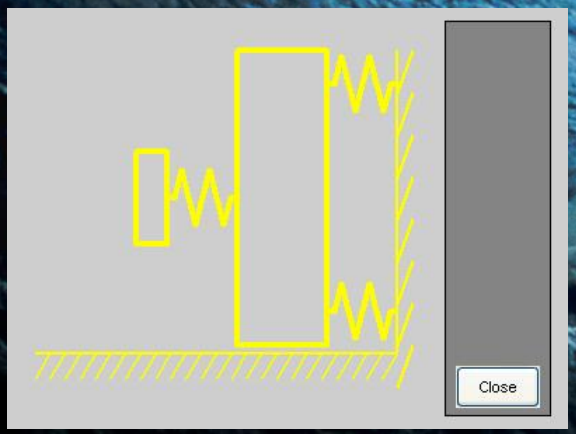
System Dynamic Modeling



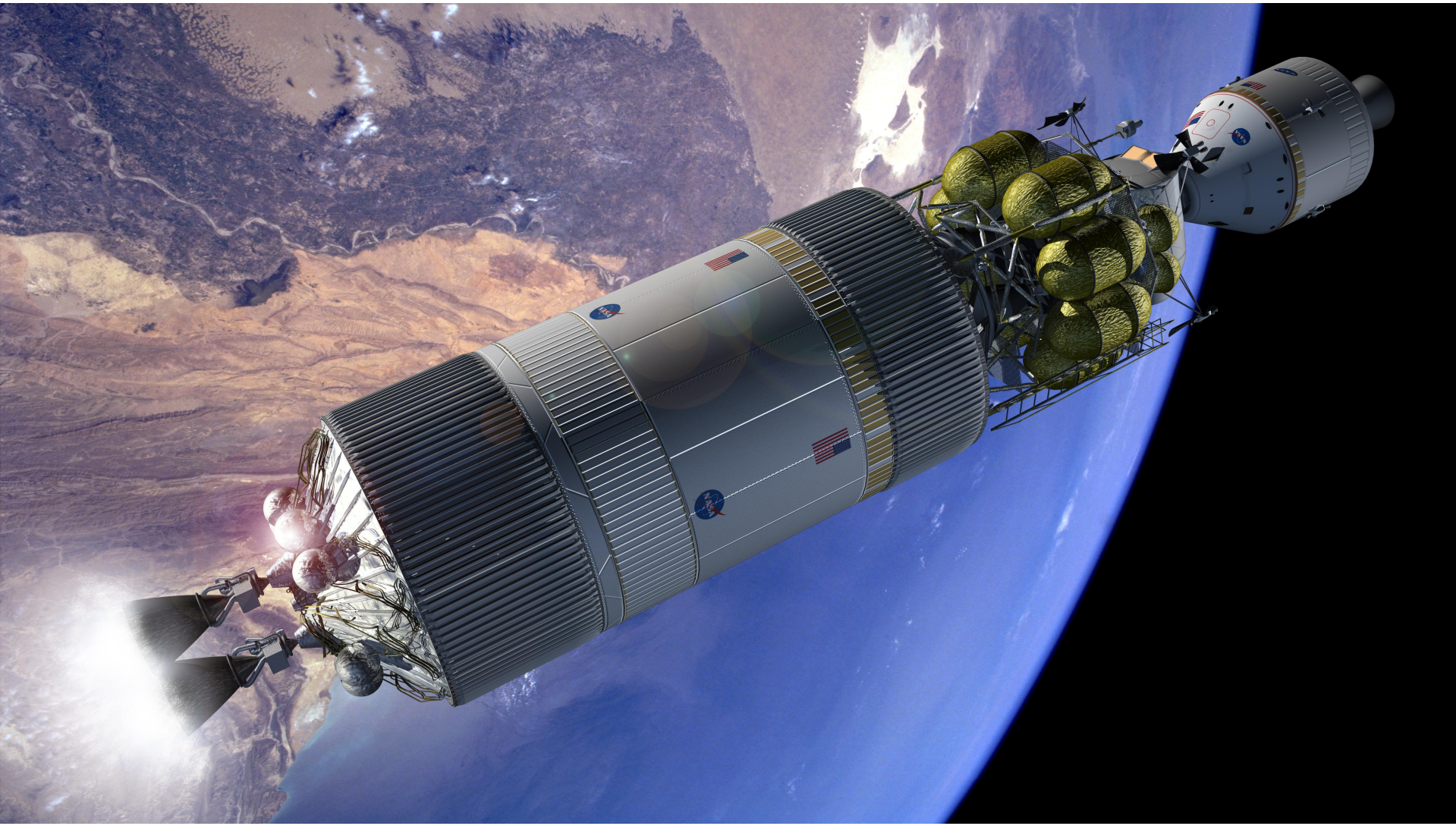
The interplay between these variables will directly affect reaction force loads on subject's musculoskeletal system:

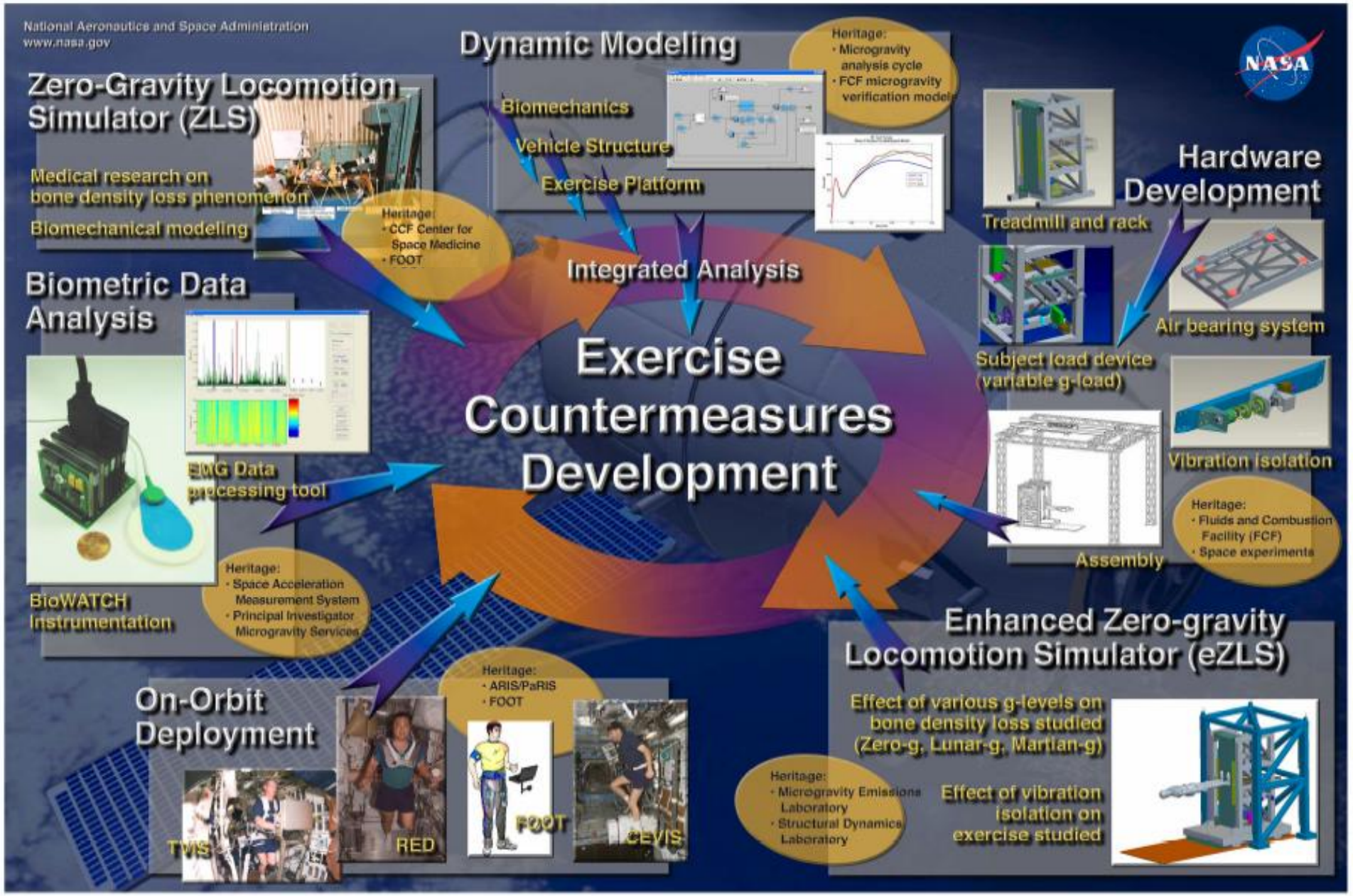
1. Biomechanics;
2. Subject Load Device (SLD);
3. Treadmill Dynamics;
4. Rack Dynamics;
5. Isolation Elements;
6. Vehicle Structural Dynamics.





Dynamic Modeling of Exercise Equipment and Interfaces for Vehicle Safety

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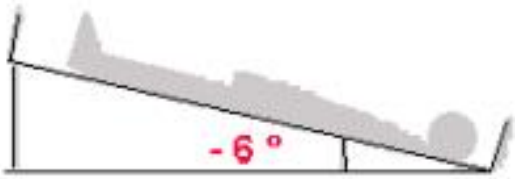
Medical research on bone density loss phenomenon
Biomechanical modeling
Heritage:
· CCF Center for Space Medicine
· FOOT
Hardware Development
Treadmill and rack
Air bearing system
Subject load device (variable g-load)
Vibration isolation
Assembly
Heritage:
· Fluids and Combustion Facility (FCF)
· Space experiments
Biometric Data Analysis
EMG Data processing tool
BioWATCH Instrumentation
Heritage:
· Space Acceleration Measurement System
· Principal Investigator Microgravity Services
On-Orbit Deployment
TVIS
RED
FOOT
CEVIS
Heritage:
· ARIS/PaRIS
· FOOT
Enhanced Zero-gravity Locomotion Simulator (eZLS)
Effect of various g-levels on bone density loss studied (Zero-g, Lunar-g, Martian-g)
Effect of vibration isolation on exercise studied
Heritage:
· Microgravity Emissions Laboratory
· Structural Dynamics Laboratory

Zero-g Locomotion Simulator (ZLS)

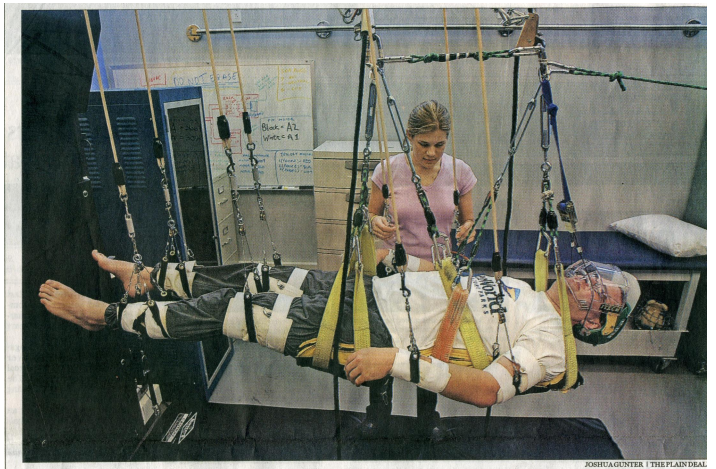
How do we simulate physiological effects of spaceflight on earth ?

For more than a decade, the 6° head down tilt **bed rest** model has been chosen as the best analog to simulate the physiological effects of microgravity exposure, similar to what astronauts experience when in space.



- Fluid shift
- Reduced physical activity
- Bone loss and muscle atrophy

Cleveland Clinic Bed Rest Study



JOSHUA GUNTER | THE PLAIN DEAL

Stephen Snitzky is "essentially weightless" while suspended four feet off the floor, says Sara Novotny, a research engineer in the Cleveland Clinic's department of biomedical engineering. Snitzky is participating in a study that will keep him in a horizontal position for 12 weeks.

Lounging around in the name of science

Study participants sent to bed for 12 weeks to evaluate zero-gravity exercise in space

SARAH TREFFINGER
Plain Dealer Reporter

Stephen Snitzky has been in bed for 26 hours.

It's Tuesday afternoon, and he has 1,990 more hours to go.

Snitzky, 31, is one of two men participating in a study of bone loss and muscle atrophy through the Cleveland Clinic's Center for Space Medicine. For 12 weeks, they will lie in bed, keeping their heads six degrees lower than their feet, which will never touch the ground, said study coordinator Ricki Englehaupt.

"They will go through just about everything an astronaut goes through," she said. The goal is to determine whether zero-gravity exercise will prevent bone loss and muscle atrophy during the 12 weeks. If successful, it may be effectively used in long-distance space travel, such as a mission to Mars.

Snitzky's bed rest began Monday at 11 a.m. It will end just in time for his November-to-April job as an office manager for H&R Block.

The two will be paid and closely monitored throughout the study, which is funded by NASA and the National Space Biomedical Research Institute. They are the only people who have passed the evaluation process, which includes a health history, an extensive physical exam, blood and urine screening, a bone density test and psychological screening, Englehaupt said. The other study participant did not want to be identified.

SEE CLINIC | B5

CLINIC

FROM B1

Study simulates astronauts' experience

Englehaupt said the researchers — led by Peter Cavanagh, chairman of the Clinic's biomedical engineering department — need a total of 24 participants over four years.

They will be randomly assigned either to a group that exercises or one that does not. Snitzky is in the latter group. Still, he will be transported five days a week to a Lerner Research Institute laboratory, where he will be suspended four feet off the floor. People in the exercise group will be positioned the same way, but they also will walk and run on a treadmill mounted vertically.

Tuesday, Snitzky spent about 20 minutes in position. A modified hockey helmet protected his head, and a suspension cradle, rock-climbing gear and long bungees supported him in a horizontal position.

When research engineers Sara Novotny and Donald Ahrens moved a bed out from under Snitzky and replaced it with a floor mat, Novotny asked how he was feeling.

"Oh, I love this," he replied. "It's like floating."

Snitzky, of Euclid, said he signed up for the study because he likes the idea of helping NASA. In his private hospital room, he has an autographed picture of John Glenn.

He also has a laptop computer, provided by the Clinic for the 12 weeks, and Internet access. Boxes of books and DVDs and a goal of learning Microsoft Office well enough to teach it should keep him occupied during his stay.

He already has accepted that he must bathe in an inflatable tub that goes on his bed. He knows that an alarm will sound if he so much as moves to the edge of that bed. And he must follow a diet designed to ensure that he does not gain or lose weight.

When the study is over, Snitzky will undergo physical therapy, two weeks of which will be mandatory, Englehaupt said.

She predicted that Snitzky will consider the completion of the study a phenomenal accomplishment.

"If you could get through this," she said, "what could you not get through? It takes self-discipline, commitment, determination and strength."

Prospective study participants must be nonsmokers between the ages of 21 and 50 and free of orthopedic injuries, bone disease and vascular disease. Call 216-445-1002.

To reach this Plain Dealer reporter: streffinger@plaind.com, 216-999-3906

The Plain Dealer | Tuesday, November 1, 2005

DAVID L ANDERSEN | THE PLAIN DEALER

Stephen Snitzky, wearing a NASA shirt, steps out of his room at the Cleveland Clinic for the first time in 12 weeks, as his mother, Fran, looks on. Helping Snitzky are Peter Cavanagh, left, and Charlie Walters of the Clinic. Cavanagh gave Snitzky a framed certificate in recognition of his commitment and dedication to "the future of space exploration."

Easy does it after long bed-rest test

12 weeks off feet in space exercise study leaves man wobbly

SARAH TREFFINGER
Plain Dealer Reporter

Whether it's one giant leap or not, it was one shaky step for Stephen Snitzky, who got out of bed Monday for the first time in 12 weeks.

Snitzky was paid to stay in bed for a study of bone loss and muscle atrophy during space travel. He read 29 books, watched more than 25 movies, studied the Microsoft Office program, read e-mails and played "probably 1,000 games" of solitaire. He also grew a beard.

The 31-year-old Euclid man will spend at least four days at a hotel on the Cleveland Clinic campus regaining his strength. Lying around is harder than you think.

The study, conducted by the Clinic's Center for Space Medicine, required Snitzky to stay horizontal and keep his head six degrees lower than his feet. His feet hadn't touched the ground since Aug. 8, when a hospital room became his temporary home. "It's a weird feeling," said Snitzky, wearing SpongeBob SquarePants slippers, as he planted his feet for his return to Earth.

Peter Cavanagh, chairman of the Clinic's biomedical engineering department, held Snitzky's hand and asked if he had any pain on the bottoms of his feet, which is what astronauts often experience when they return from space.

"A little," Snitzky told him. "Put it this way: I wouldn't want you to let go."

As a small crowd looked on, Snitzky walked out of his room, into the hallway and then back to his bed several times with help.

Snitzky and another man, who did not want to be identified, participated in the study, which will continue in January. Cavanagh said he needs 22 more participants. They will be randomly assigned either to a group that exercises or one that does not.

Snitzky did not. Five days a week, he was briefly suspended four feet off the floor in a horizontal position to simulate weightlessness. If he had been in the exercise group, he would have been supported in the same way as he walked and ran on a treadmill mounted vertically.

The goal of the study is to determine whether zero-gravity exercise will prevent bone loss and muscle atrophy. If it does, it could be used in long-distance space travel. NASA and the National Space Biomedical Research Institute are funding the study. Cavanagh said Snitzky will be closely supervised for the rest of this week and will undergo eight weeks of physical therapy. He can expect to have some joint pain and to be wobbly going around corners.

In January, Snitzky will return to his job, which is a little more taxing than his Clinic gig. He's the manager at H&R Block in the Great Lakes Mall.

"Daily Load Stimulus" (DLS) Theory

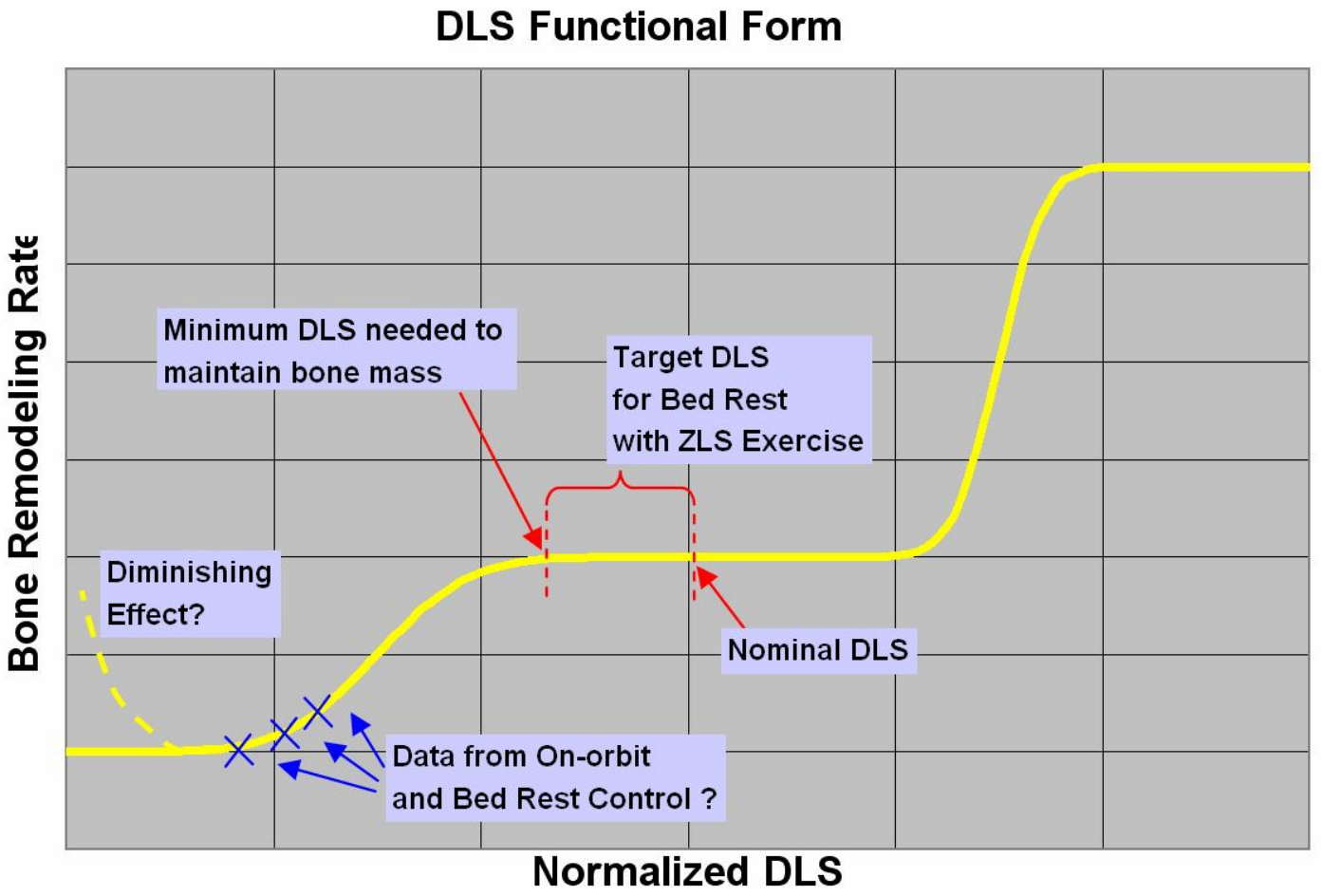
$$\rho \propto \left[\sum_{j=1}^{k} n_j \left(\overline{\sigma}_j \right)^m \right]^{1/2m}$$

Mathematical theory based on the amount of cyclic strain energy stored within the bone matrix.

Using to develop exercise prescriptions (dose)

Carter, et. al. (1987)

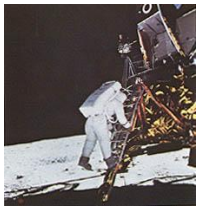
“Error Function” Form of DLS



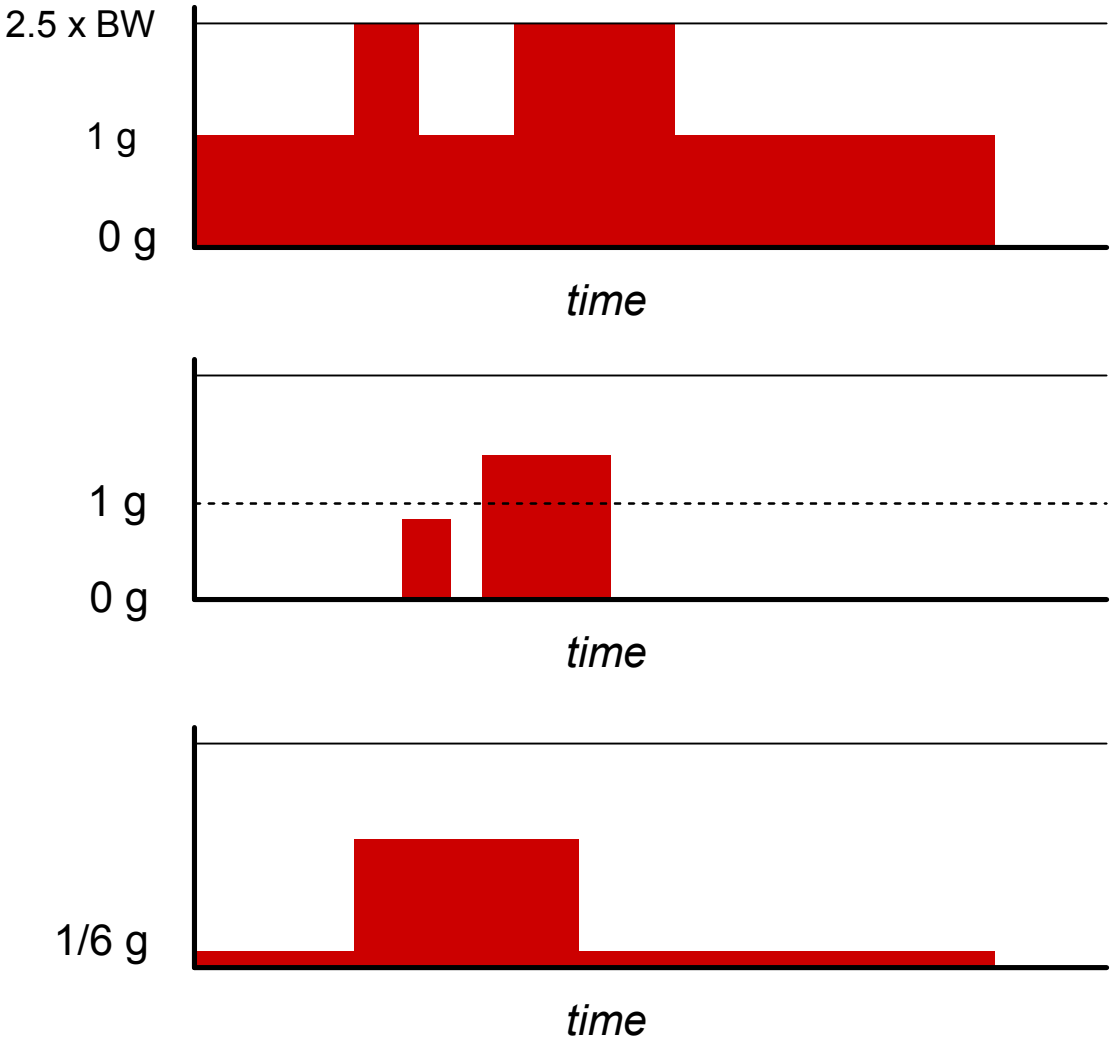
Do We Need to Replace 1g Loads in Space ?

Earth

On-orbit



Lunar



Subject Load Device

ZLS at Cleveland Clinic – Linear Motor Subject Load Device (LM-SLD) Demonstration

Subject Loading – Pneumatic

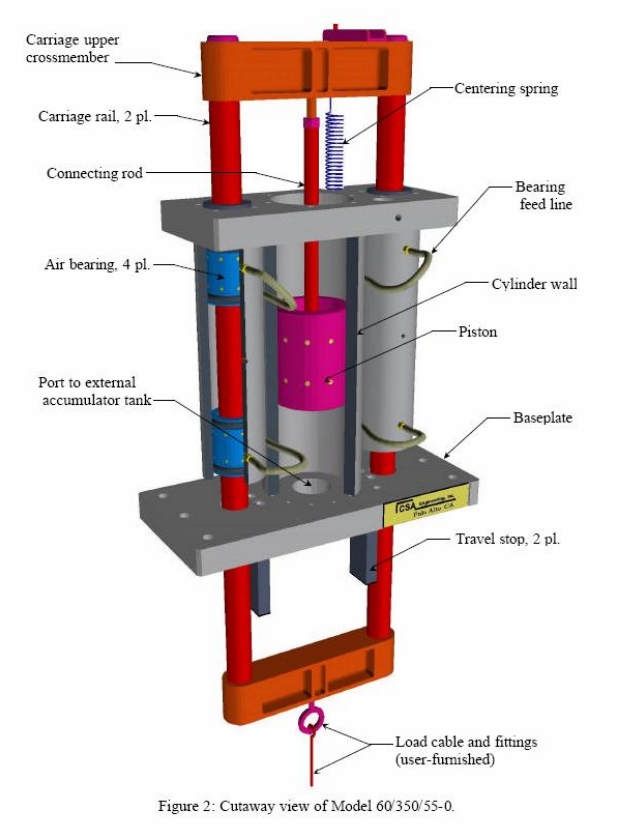
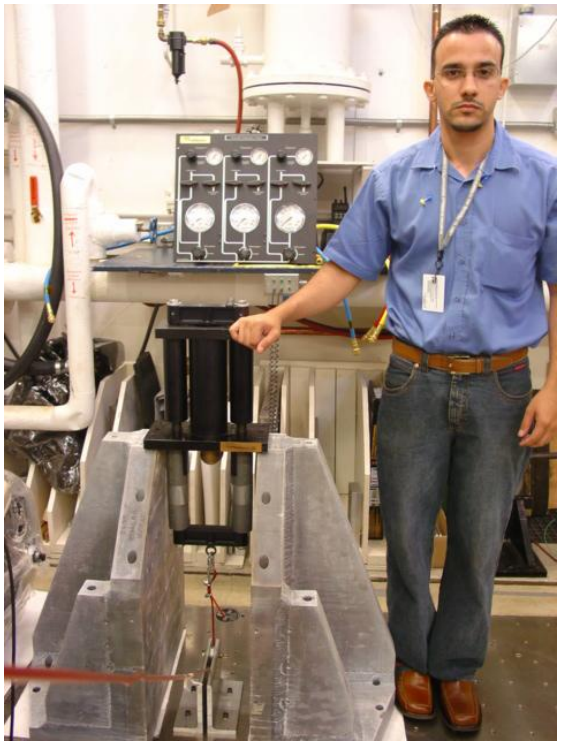
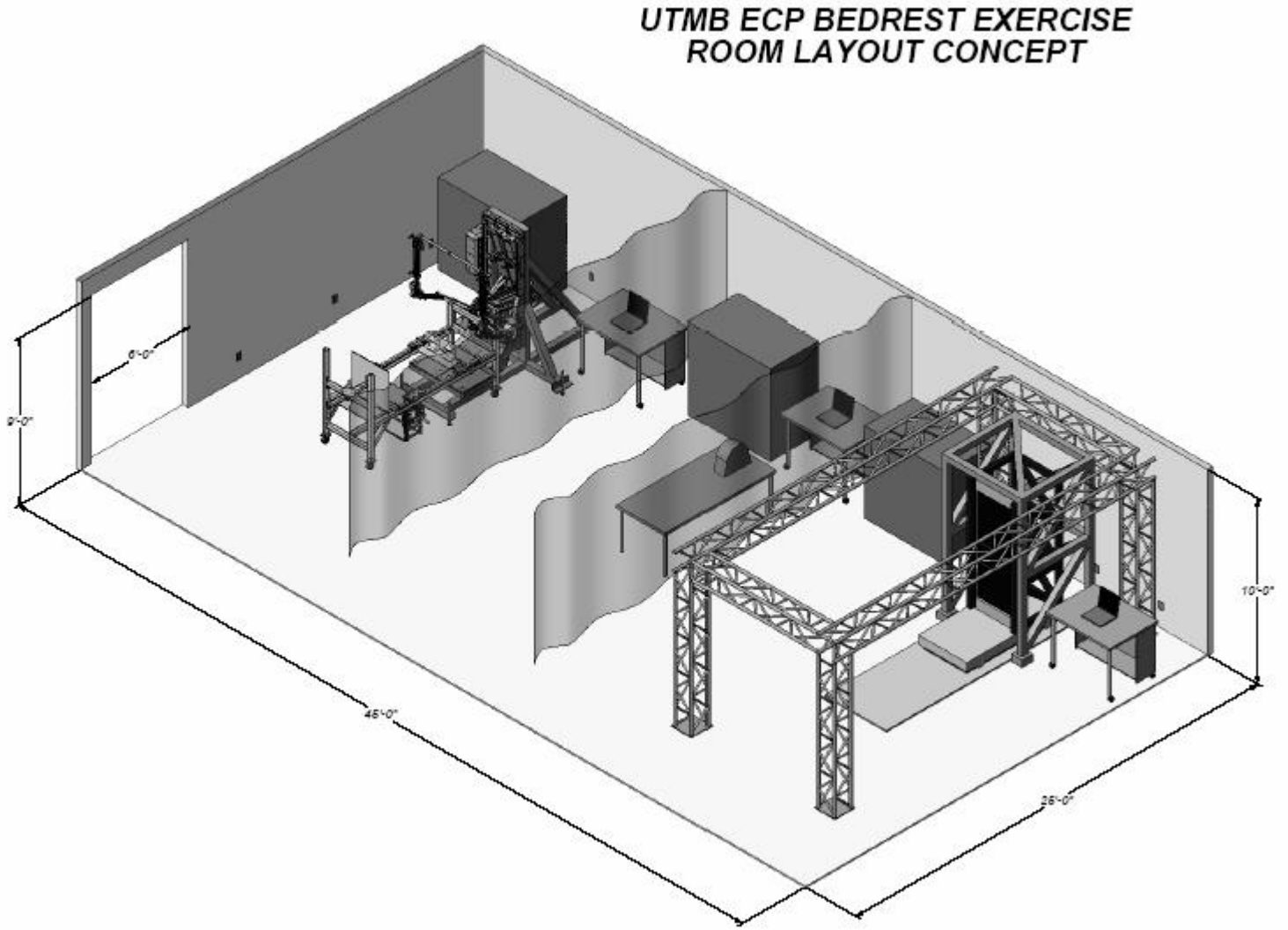


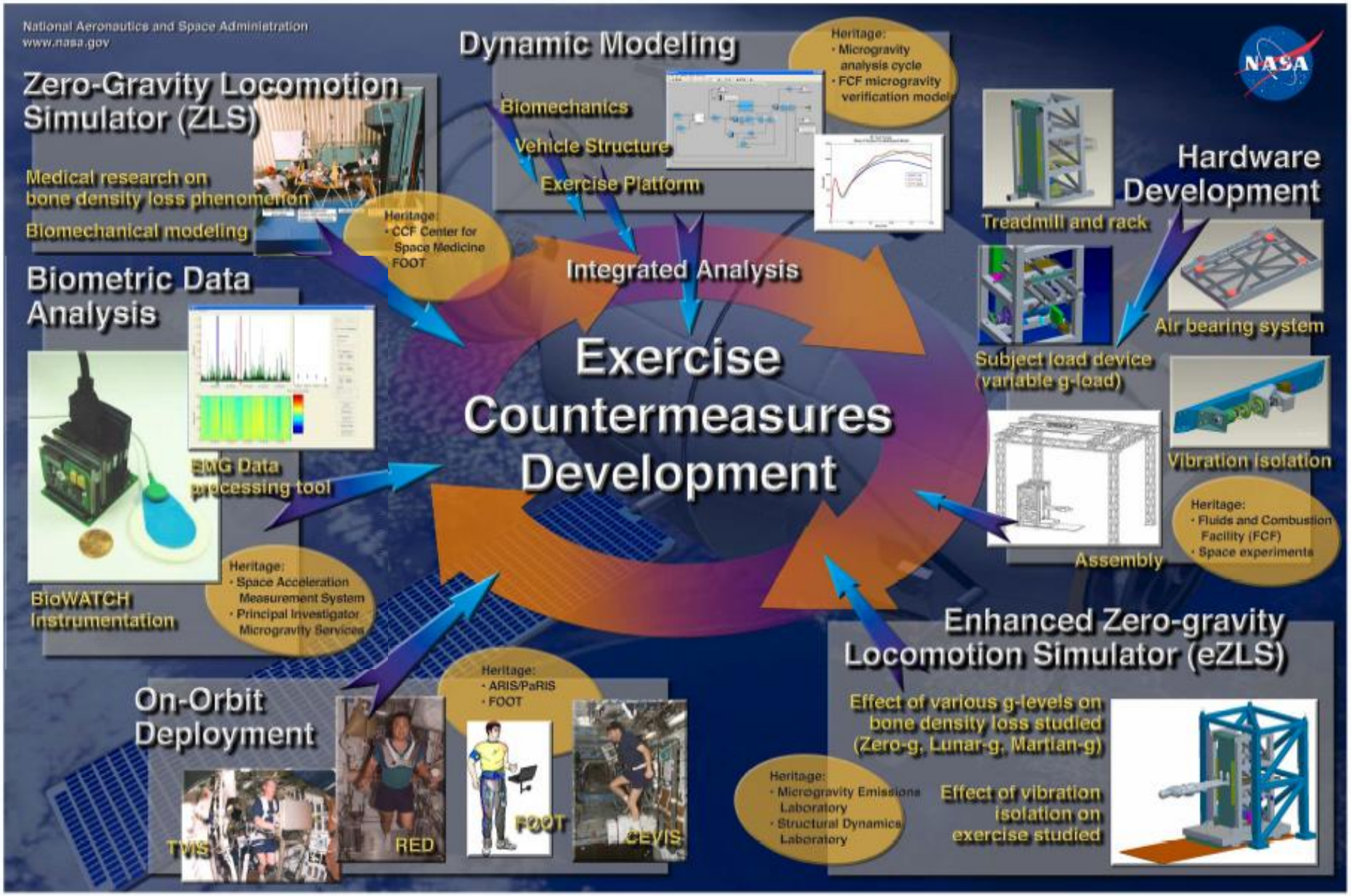
Figure 2: Cutaway view of Model 60/350/55-0.



Proof – of - concept testing at GRC

Standalone ZLS for JSC Bedrest Campaign




National Aeronautics and Space Administration
www.nasa.gov
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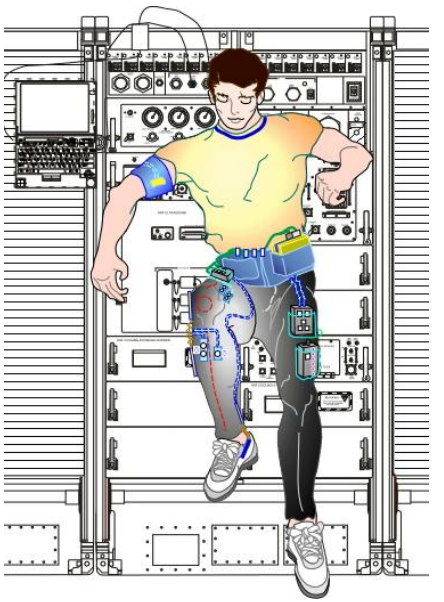
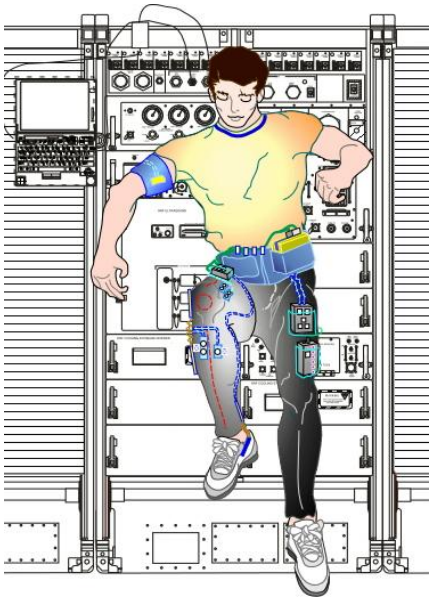
Biometric Data Processing and Analysis

FOOT Experiment on ISS



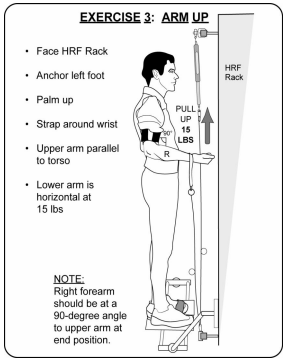
Biometric Data Processing and Analysis

NASA GRC/ ZIN Technologies
-Assisting Cleveland Clinic in developing EMG Data Processing tool for the ISS FOOT Experiment



FOOT Experiment

- Surface EMG (Electromyography)
- Muscle Activity
- 7 Muscles in right arm and leg
- Surface Electrodes
- Data taken over 12 hour session several times per increment
- Calibration performed using isometric exercises at beginning of session
  - ➢ Output signal from muscle varies from day to day and person to person.
- Relaxed Muscle Level (Muscle Activation threshold also performed

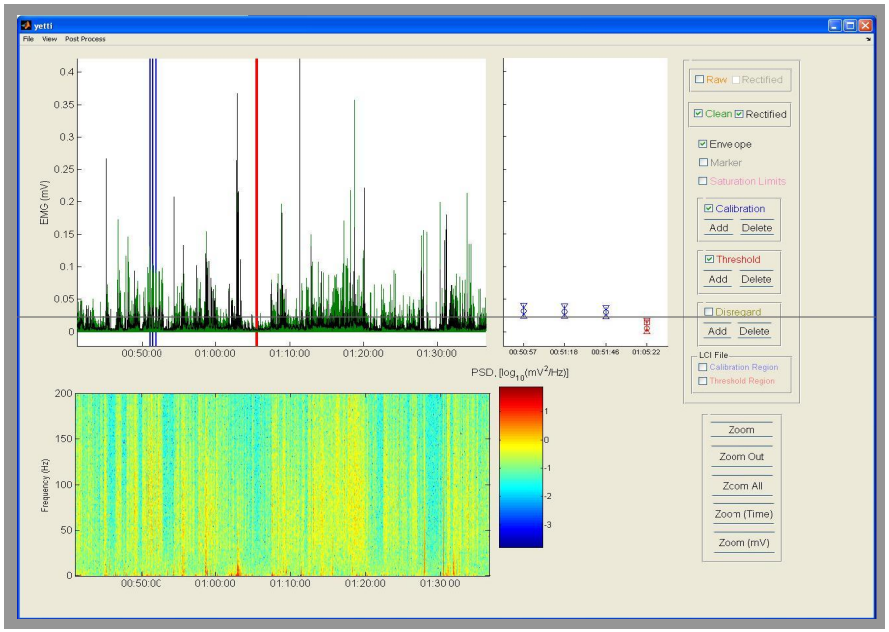


Biometric Data Processing and Analysis

Pre-Processing

- Data Handling of Large Files
  (1024 Hz * 8 hrs=29 million samples/file!)
- Merging of EMG and Marker Data
- Debiasing*
- Noise Filtering*
- Automated Calibration Period Focusing*
- Calibration and Threshold Statistics*
- Spectral Analysis*
- Sensor Saturation Identification

*User Selectable Parameters



Post Processing

- Normalized EMG (using calibration)
- Calculation of NND
- Graphical Display of Cumulative NND
- Muscle Activation Periods (EMG>Threshold)

ZIN Technologies

THE CLEVELAND CLINIC FOUNDATION

Biometric Data -- BioWATCH

BioWATCH - Biomedical Wireless Ambulatory Telemetry for Crew Health

A Compact Wireless BioMetric Monitoring and Real Time Processing System

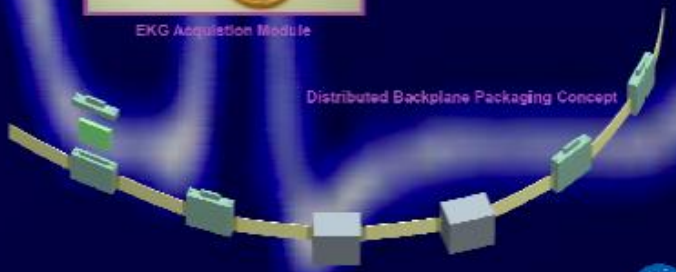
SENSOR MODULES
- •EKG (3,6,12 Lead)
- •EEG
- •EMG
- •Pulse Oximetry
- •Plantar Pressure
- •Joint Angle
- •Blood Pressure*
- •Core Temperature*
- •Blood Glucose*

*Generic Digital I/O
-RS-232, USB, Ethernet

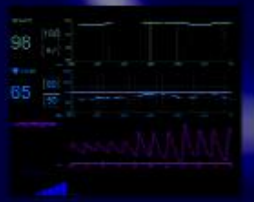
MONITORING UNIT
- •Compact
- •1GB On-board Storage
- •Wireless Data Transmission
- •Ethernet Hardwire Transmission
- •Extensible Sensor Capabilities
- •Modular Design (4 Sensor Module "Slots")

Monitoring Unit (Engineering Development Unit)

EKG Acquisition Module



Distributed Backplane Packaging Concept



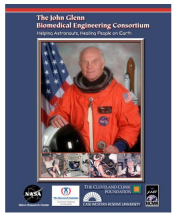
Bettering the State of the Art Signal Acquisition

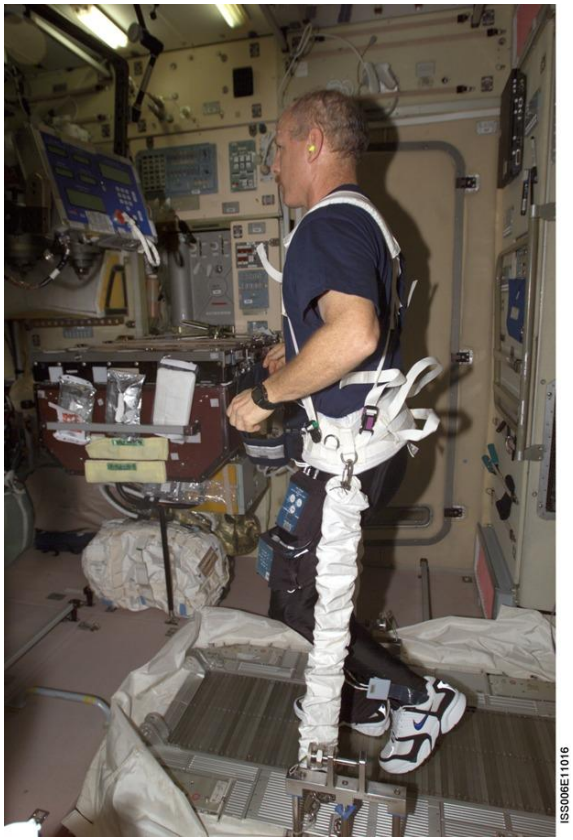
BioWATCH will not only be the most compact and modular system available, it will improve on the current state-of-the-art biological signal fidelity. For example, EMG sensor modules will have individual channel auto-ranging. This will allow for accurate measurement across all activities levels without signal saturation. Additionally better than 120dB of dynamic range will be realized as the current industry standard of 12 bit digitization will be doubled to 24 bit

Performed under NASA Phase I SBIR Contract NNC05CA85C

Real-Time Feedback for Exercise Prescriptions

Real-Time Feedback for Exercise Prescriptions

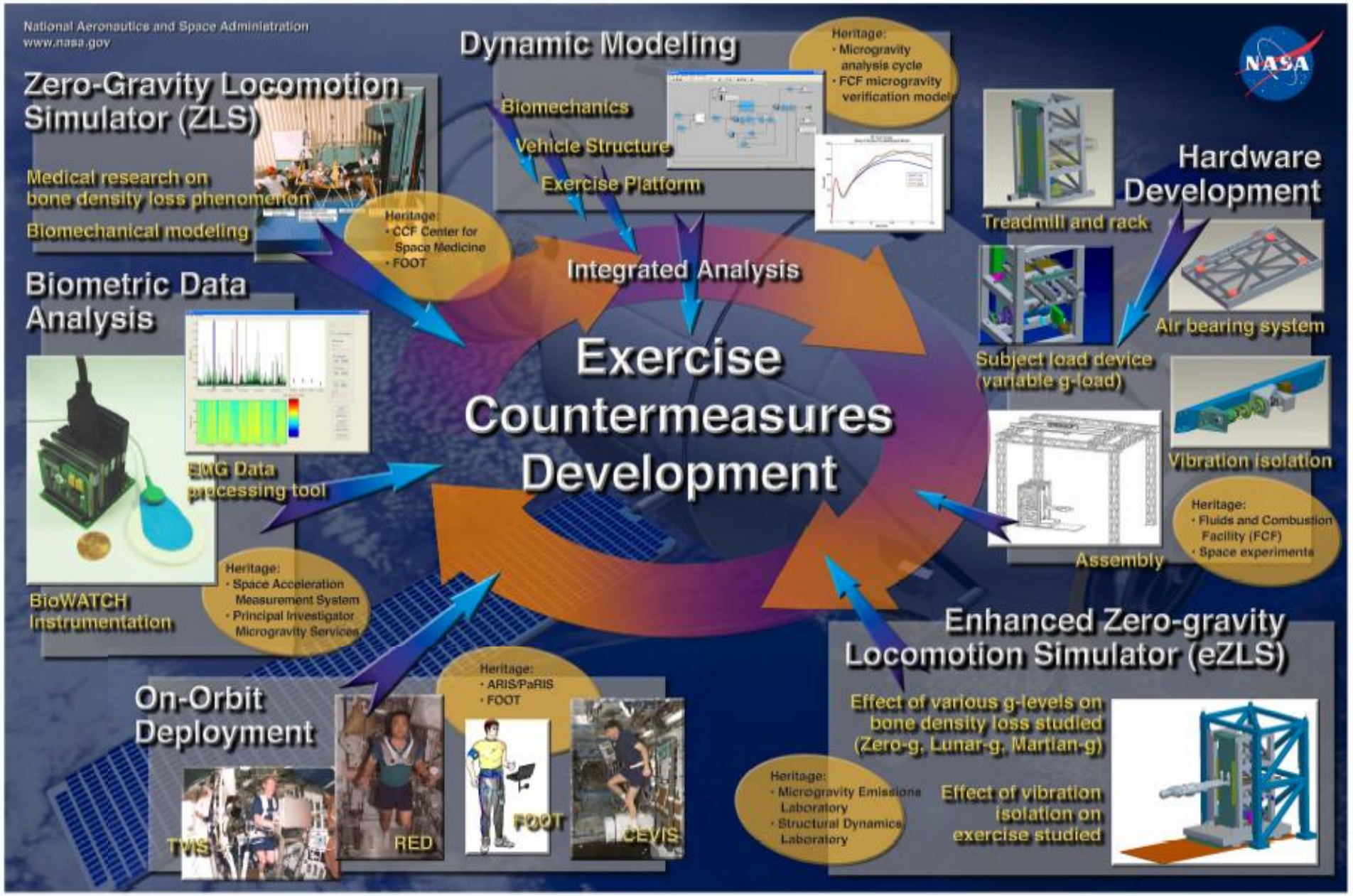




DLS Calculator
with display

Measure of “actual” exercise dose vs. prescribed

-- *based on directly measured force parameters*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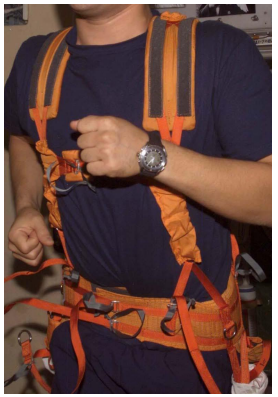
Crew Equipment Optimization

ISS Treadmill Harnesses



Russian

U.S.

U.S. /Russian

Cleveland Clinic Prototype

Crew Equipment Optimization

I'M A RUNNER

LEROY CHIAO
NASA Astronaut, 44, Houston

ders that weigh as much as you do. It gets *heavy*.

The fastest you can run on the treadmill is a 10-minute-per-mile pace—but the added weight on your shoulders tires you out.

The harness gave me hot spots, and I had to use duct tape to protect my skin, which didn't work very well—I have a couple scars from it.

In space sweat beads up on your face instead of running down it.

Dehydrated mashed potatoes with onions—they're really tasty and a great source of carbs.

I grew up in the Bay Area and used to run races for fun. One of my favorites was the "Run to the Far Side" in Golden Gate Park. Gary Larson would run every year wearing number "00."

Of all the exercises I do, running hurts the most—so it must be doing me *the most good. I plan* to keep running until I'm way past the point where I have any business doing it.

To read the full interview, see runnersworld.com/imarunner

INTERVIEW BY
JOANNA SAYAGO

I watched the first Apollo moon landing as an eight-year-old kid [in 1969]. That's what inspired me to be an astronaut. Lots of kids say they want to be one, but I never forgot the dream.

Being fit is important to being an astronaut. If we didn't work out in space, our muscles and heart would have a hard time readjusting to gravity on Earth.

I typically run three or four days a week, between two and four miles. But I'm short-legged, so I'm not that fast.

I've been at NASA for 15 years and flown three shuttle missions. We always had workout equipment but never a treadmill. But on my most recent mission, I was on the International Space Station for 193 days [from last October to April], and the treadmill was an integral part of our exercise regimen.

In space we conduct experiments that are sensitive to vibrations. So NASA built us a special treadmill that uses fly wheels, gyroscopes, and springs that damp out pounding.

Because there's no gravity, I needed to be strapped down with a harness that goes over my shoulders and attaches to the treadmill with bungee cords. The cords pull the harness down on my shoulders. It's like running with dumbbells on your shoul-

"The harness gave me hot spots…I have a couple of scars from it"

Leroy Chiao, NASA Astronaut

Crew Equipment Optimization

90 lb. pack is considered *heavy* !

Using backpack industry best practices

- Load distribution between hips and shoulders
- Moldable thermoplastic
- Split loading around illiac crest

Backpack Design

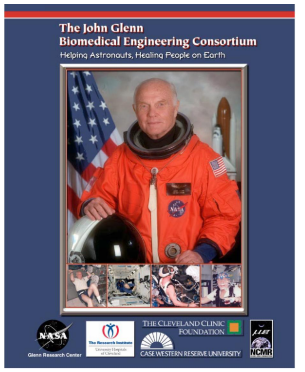
Cleveland Clinic Prototype

Research Collaborations
GRC / Others

- National Space Biomedical Research Institute
  - Cleveland Clinic Bedrest Study – Ground-based analog to spaceflight
  - Cleveland Clinic / NASA GRC / Zin Technologies
    - Enhanced Zero-g Locomotion Simulation / Analytical Modeling
- NASA Johnson Space Center – Exercise Countermeasures Project
- John Glenn Biomedical Engineering Consortium
  - ISS Treadmill Harness Re-Design / Optimization
  - Exercise Prescription Development for Bone Mass Maintenance / Crew Feedback
- CSU Technology Commercialization Grant and SBIR Grant
  - BioWATCH development

Strategic Partnerships / Grants

John Glenn Biomedical Engineering Consortium



Members: Case Western Reserve University (CWRU)
Cleveland Clinic Foundation (CCF)
University Hospitals of Cleveland (UHC)
National Center for Space Exploration Research (NCSER)
NASA Glenn Research Center (GRC)

Focus: Space Act Agreement with Case Western Reserve University, Cleveland Clinic Foundation, University Hospitals of Cleveland, the National Center for Space Exploration Research to perform interdisciplinary research leveraging GRC expertise in fluid physics and sensor technology to mitigate critical risks to crew health, safety, and performance identified in the Bioastronautics Roadmap.

Resources: 7.5 M over three years ending July 2005
Member personnel, facilities, capabilities, leveraging and in-kind contributions

National Space Biomedical Research Institute

- Primary mission is to ensure safe and productive human space flight.
- Consortium of 12 institutions working to prevent or solve health problems related to long-duration space travel and prolonged exposure to microgravity.
- NSBRI discoveries and research will lead to countermeasures to the harmful effects of microgravity and space radiation.
- Bring discoveries and products of clinical benefit to Earth.
- Established in 1997

Cleveland Clinic Center for Space Medicine

Established via Space Act Agreement to provide an environment and mechanism to promote interdisciplinary research that will exploit the unique skills, capabilities, and facilities of both CCF and NASA GRC in support of long duration spaceflight.

Questions ?